DOCUMENT RESUME

ED 196 921 SP 017 441

AUTHOR Donald, Janet Gail
TITLE Psychology's Contribution To Teaching: Educational Epistemology.
SPONS AGENCY Social Sciences and Humanities Research Council of Canada, Ottawa (Ontario).
PUB DATE Sep 80
NOTE 30p.: Paper presented at the Annual Meeting of the American Psychological Association (Montreal, Canada, September, 1980).

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Abstract Reasoning; *Associative Learning; Cognitive Processes; College Instruction; *Concept Formation; Concept Teaching; Course Organization; *Educational Psychology; *Epistemology; *Evaluation Methods; Higher Education; Learning Processes; Teaching Methods

ABSTRACT

The contributions of psychology, theoretically and experimentally, to university teaching are examined from the perspective of educational epistemology. The most basic theoretical contribution that psychology has made to cognitive learning has been the delineation of a unit of thinking, the concept, which acts as an organizer of experience. The methods of evaluating concepts and the different forms of representation in a cross disciplinary study revealed trends across disciplines and baseline variability among learning tasks in different courses. The methods of evaluating concepts include measures of the frequency and familiarity of key concepts, and measures of word associations to the concepts. The methods of representing concepts in a cognitive structure produced tree structures and similarity matrices. These could then be rated for consistency and for the kinds of relationships between concepts. (Author/JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED196921

PSYCHOLOGY'S CONTRIBUTION TO TEACHING:

EDUCATIONAL EPISTEMOLOGY

Janet Gail Donald, PhD, McGill University

Paper presented in a symposium on "Psychology's Contribution to Teaching: Past, Present and Prospective" at the annual meeting of the American Psychological Association, Montreal, September 1980.

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Janet Gail Donald

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

The research reported in this paper was supported by grants from the Social Science and Humanities Research Council of Canada and the Quebec program for the "Formation de chercheurs et d'action concertée." Requests for reprints should be sent to Dr. Janet J. Donald, Centre for Teaching and Learning Services, McGill University.

SP 017 441

Psychology's Contribution to Teaching:

Educational Epistemology

Abstract

The contributions of psychology, theoretically, methodologically, and experimentally, to university teaching, from the perspective of educational epistemology, are those which provide answers to the question "What constitutes good learning in a course?" The most basic theoretical contribution that psychology has made to cognitive learning has been the delineation of a unit of thinking, the concept, which acts as an organizer of experience. Concepts are related to each other to form a cognitive structure. These expressions, "concept" and "cognitive structure," have been shown to be useful to professors in describing what is to be learned in a university course and in representing it. The methods of evaluating concepts and the different forms of representation in a cross disciplinary study revealed trends across disciplines and baseline variability among learning tasks in different courses. The methods of evaluating concepts included measures of the frequency and familiarity of key concepts, and of word associations to the concepts. The methods of representing concepts in a cognitive structure produced tree structures and similarity matrices. These could then be rated for consistency and for the kinds of relationships between concepts.

The experimental contributions that psychology has made to cognitive learning are more diverse. They include work on modes of learning, on the effect of abstraction and generalization in the learning process, and on the results of different relationships between concepts on teaching and learning. The specific import of these results lies in the suggestions they make about the nature of the thought processes or strategies required to comprehend course material.

PSYCHOLOGY'S CONTRIBUTION TO TEACHING:

EDUCATIONAL EPISTEMOLOGY

I. THEORETICAL

- The concept: a unit of thought
- Cognitive structure

II. METHODOLOGICAL

- Quantification of concepts
- Frequency, familiarity and association measures
- Representation of relationships

III. EXPERIMENTAL

- Modes of learning
- Abstraction
- Generalization
- Salience
- Kinds of relationship

IV. SYNTHESIS

- What constitutes good learning in a course?

Psychology's Contribution to Teaching:
Educational Epistemology

Janet G. Donald

McGill University

The theories and practices of psychology which have garnered greatest fame in the world of university instruction are those which come from the subfields of learning and of measurement and evaluation. The university professor is concerned about which teaching methods will best serve the purposes of learning, and about how to evaluate student learning. My experience as a teaching and learning consultant in the university has led me, however, to adopt a mildly revisionary perspective: that is to say, although learning and evaluation processes still dominate my everyday life, I look increasingly for answers in the field of cognitive processes or epistemology. I do this for two reasons. First, I have found that the learning process depends heavily on its content, on what is being taught. The concepts and relationships in a particular course determine how that course can be taught and how students may learn it. Second, in order to evaluate student learning, it is necessary to first understand what is to be evaluated, that is, what knowledge and abilities the student is expected to acquire during a specific learning period. My definition of teaching is, then, for the sake of argument: the organization of concepts, and the analysis and synthesis of their relationships. I should interject that this definition of teaching

may appear to be original, if not bizarre; but it is what students consider to be good teaching (Hildebrand, Wilson & Dienst, 1971; McKeachie, 1969). Educational epistemology then becomes the basic science for the applied science of teaching.

The contributions that psychology has made and will make in the future to teaching through educational epistemology are of three kinds: theoretical, methodological, and experimental. The two most important theoretical contributions that psychology has made to my work and thinking are in the definition of a concept and of cognitive structure. Methodologically, psychology has contributed to the quantification of course concepts, to measurements of the occurrence and associative properties of concepts, and most importantly, to the representation of concepts and their relationships. Experimentally, there are the results of imaginal learning compared to verbal learning; the effects of abstraction, generality, and salience on learning and retention; and the effect of relationships between concepts and their placement in prose learning materials or their order of presentation: these results suggest important effects due to learning content and its organization.

Theoretical Contributions

The most basic theoretical contribution that psychology has made to cognitive learning has been the delineation of a unit of thinking. This unit, the concept, was first given prominence by Bruner et al. (1956) in their book A study of thinking. A concept

was considered to be an organizer of experience, which enabled us to categorize and therefore to gain a measure of stability and clarity or definiteness over our universe. In behavioral terms, concept learning was defined by Hunt (1962) as a situation in which someone learns to make an identifying response to members of a set of not completely identical stimuli. This is a much broader definition than the standard dictionary definition which describes a concept as an idea or abstraction. For Hunt, the concept learner was held to be creating a classification rule. Olson (1963) also took this line of thinking when he investigated concept learning in the classroom. In the learning process, related concepts were integrated to become a hierarchy of mediators of greater generality. The verbal rules or concepts which were related could be organized into more generic verbal coding systems, which would in turn provide a systematic symbol system that could integrate and make sense out of a broad range of phenomena.

Other researchers have further clarified the meaning of the word "concept" in terms of its functions and parameters. Nelson (1977) defined a concept as organized information that is not dependent upon the immediate perceptual array and is at least potentially nameable. Concepts exist at varying levels of generality and abstraction and may vary from simple to extremely complex. A concept is not necessarily a class or category, though it may be. Concepts exist within a conceptual framework and this framework may take different forms, including propositions, scripts, or categories.

A concept is not considered to be a discrete entity. In theory, boundaries for any given concept merge more or less indefinitely with those of another concept. There is, however, a center of density for a given concept, which, in the framework of associative meaning, can be represented by the stimulus word which overlaps the most with other stimuli in the collection comprising the concept (Deese, 1965). This description of a concept is analogous with the term "factor" and points out the inherent fuzziness of the definition. There are, however, more or less fuzzy concepts, and in spite of the inherent fuzziness, concepts can be represented as discrete entities. In the representation of memory, a concept is a node or cluster of information which corresponds to an object or idea that can be named or described (Rumelhart, Lindsay & Norman, 1972). Concepts then have the role of a beacon or a buoy in a sea of probabilities. They are centering points which clarify and stabilize thinking.

The value of concepts as units of thought to the teaching process may already be evident. They act as points of departure for course planning, instruction, and evaluation. They control the kind of presentation and the kind of thought strategies that can occur in the classroom. In short, they provide the basis for course organization. The nature of this organization is the other important theoretical contribution that psychology has made to educational epistemology.

Concepts are related to each other and form some kind of structure. The nature of this structure appears to exert a powerful influence on learning (Johnson, 1973). The earliest description of such a structure

was Herbart's 19th century concept of an "apperceptive mass" inside the learner, which was the organized totality of past experiences in the human mind, and which interacted with new experiences to produce learning. Relabelled "cognitive structure" in the 20th century, Ausubel (1968) defined it as the substantive content and the major organizational properties of a structure of knowledge. It is important for instructional purposes to distinguish between cognitive structure and content structure. Although Bruner (1960) defined structure as the underlying principles and attitudes toward inquiry inherent in a particular subject matter, Ausubel's definition was related more to the internal patterns of thinking of the learner. The two concepts overlap, but whereas the content structure of a course can be defined as the web of concepts and their interrelations in a body of material, and thus has an objective existence, a cognitive structure is internal and perhaps idiosyncratic to the learner or professor.

Why is cognitive structure important? Claimed to be the most significant learner variable and defined as the basis of practically all educational theory (English & English, 1958), cognitive structure has a particular significance in higher education. Approaches to learning that deal with behavior, performance, skills or competence all have value in the university. The crucial function of the university is, however, the creation and dissemination of knowledge. This demands an approach which elucidates the cognitive or meaningful verbal learning operations which deal with information in complex

configurations. How to encode and retain abstract and propositional knowledge in long-term memory is the problem of everyone in the university.

Generally speaking, research shows that learners segment learning materials into integrated groups or chunks or categories which become their functional recall units. A paradigm or a proposition, a theme or a concept may serve the chunking or locating purpose. If the organization of the groups or chunks is disturbed, for example, if after learning to categorize according to use, the learner is required to categorize according to shape, recall suffers. Bower (1970) points out the particular effectiveness of a hierarchically embedded category system in producing recall. Cognitive structure provides a paradigm for tracing and locating information quickly and readily. A structure of particular concepts and relationships acts as a unit of memory itself and is sometimes more readily retrieved. For example, superordinate levels of information, which could be supposed to be more difficult to learn, are retained in memory better than subordinate levels, whether the information consists of concepts, propositions, or units as large as biographies (Bower, 1974; Kintsch & Keenan, 1973; Meyer & McConkie, 1973; Miller, Perry & Cunningham, 1976). Higher order concepts or structures, therefore, appear to have greater power than subordinate ones. The concept of cognitive structure enables us to deal with the encoding, abstracting, paraphrasing, and retrieving of knowledge in the individual learner or teacher.

Methodological Contributions

Very often in the domain of teaching and of education in general, when a problem is recognized, the greatest barrier to its solution is the lack of formal or scientific methodology. Several methods that have been derived and tested in psychological experimentation are valuable to educational epistemology. Some of the methods would appear simple and obvious to psychologists, although they are novel to educational epistemology; others are more complex. One simple and obvious method was to count the number of relevant and the number of important concepts in a course. In my study of sixteen university courses across disciplines, one of the first clear differences found was in the number of concepts students could be expected to learn in a course. For a one semester course, the number ranged from 33 to 170 concepts; and the number of important or core concepts ranged from 10 to 59 (see Table 1). These ranges show the baseline variability among learning tasks in the different courses, and they suggest one source of comparative learning difficulty. A more sophisticated procedure was the use of the Kučera-Francis computational analysis of the frequency of occurrence of words in present-day American English (1967). This word count was based on a corpus of over one million words of natural language text in which over 50,000 distinct graphic words occurred. A Kučera-Francis rating was therefore the number of times a concept appeared in the corpus of over one million words of prose (see Table 2). The rating provided an index of concept familiarity which was an indicator of course concept difficulty and it

highlighted those courses in which more basic vocabulary learning would be required because of unfamiliar concepts. The research project which begins this fall will examine if indeed those concepts rated as unfamiliar or technical are present in the student's entering vocabulary in a course.

Another method which has a long history in psychology but has not previously been used to analyze learning tasks in education is word association. Deese (1965), Marshall and Cofer (1963) and Miller (1971) have utilized word association methods to determine semantic relatedness or concept meaningfulness. Word association data can be used to indicate how related two concepts are, based on the number of identical associations made to them; concept cohesiveness, or how alike word associations to a concept are; and how a concept fits into a theoretical structure, judged by the frequency of a particular category of response to a given word. In my study, each professor did word associations for the key concepts in his or her course, ranging from 7 to 20 key concepts. The average number of word associations given in one minute per concept in a course ranged from 3.8 to 12.8, suggesting a wide range of concept richness or elaboration across courses (see Table 2). For each pair of key concepts linked in a course tree structure, a relatedness coefficient, which is the ratio of the overlap of associations between two key concepts to the maximum possible overlap, was determined according to the method developed by Garskof and Houston (1963). The science courses, particularly chemistry and physics, showed relatively high

mean relatedness coefficients compared to social sciences and humanities courses, although the philosophy course registered the third highest mean. This suggests a tighter relationship structure in the sciences and in a synoptic course such as philosophy. The relatedness coefficients were not, however, particularly high, with a mean overall of .117, which suggests that key concepts are chosen because they represent distinct entities in the structure of the course. Word association techniques might show more noticeable results within topic areas or course modules.

The most complex psychological methods employed in this study were those of representations or schemas of the professors' cognitive structures. The origin of these methods is in Bartlett's concept of a schema as the active organization of past experience. Schemata are considered to be data structures for representing the generic concepts stored in memory (Rumelhart & Ortony, 1977). A schema contains a network of interrelationships and is intended to show not only the data structure but also the interrelating structural procedures. It is therefore both active and passive and provides information not only about what is to be learned but also about how it can be learned, that is, the thought strategies or relationships involved. A number of researchers have worked with graphic representations, including Frase (1969); Fredericksen (1972); Kintsch (1972); Preece (1976); Rapoport (1967); and Shavelson (1974).

Two representational methods were used in the study of professors' course cognitive structure. The first was a tree structure method which

showed proximity relationships between concepts in a linear ranking, that is, the two most closely related concepts were linked by line number 1, the second most closely related concepts by line number 2, etcetera. The tree structure thus revealed the most dominant relationships among the key concepts but did not reveal all the relationships between them. One of the important findings of my study was that different patterns of relationships emerged in different disciplines. For example, in the sciences, the most common pattern was a tight, hierarchical structure with several levels of concepts and many links between them (see figure 1). In contrast, the most common pattern in social science courses was a web with a group of concepts centered around a pivot concept, while in humanities courses, the pattern tended to be linear, with fewer links overall (see figures 2 and 3). The implications of these structures for teaching and learning are manifold. In the sciences, the tight structure suggests that students have a relatively clear and convergent learning task, and it also explains the all-or-none learning tendency in the sciences: students either acquire the complex structure or they do not. Once acquired, there are many supporting relationships to aid retention.

In the social sciences, however, the structure tends to be much looser, and the dominant pattern shows a cluster. This suggests that the teaching/learning process may revolve around certain central or pivot concepts. If these are learned, they then link the other course concepts. In the humanities, the learning task is once again

different, and the linear pattern suggests that each concept must be learned on its own, which presents a different kind of learning task.

The second representational method was based on the professors' judgment of how closely related in meaning each pair of key concepts was. This method of subjective scaling or magnitude estimation, used by Eignor (1978); Miller (1971) and Rubenstein and Goodenough (1965), provided a non-constrained or independent measure of concept relatedness between each pair of key concepts. These relationships were then used to produce a visual representation of the structure according to Waern's (1972) procedure. This topographical representation revealed further dimensions or relationships between concepts and acted as a consistency check for the tree structure relationships. Those links designated as closest in the tree structure could be compared with their relatedness of meaning ratings for consistency of signification. Inconsistent links could then be examined more closely to determine the nature of the relationship and why it provoked an inconsistency.

Experimental Contributions

The experimental contributions that psychology has made to cognitive learning are more diverse. Bruner's (1964) work on modes of learning: enactive or sensori-motor; iconic or graphic; and symbolic, suggests different patterns of cognitive structuring based on different modes of representation. Researchers in imaginal learning such as Paivio (1974) have pointed out that verbal and non-verbal or perceptual information are processed in different ways.

Several studies have shown that a combination of verbal and graphic presentation lead to increased learning (Rigney & Lutz, 1976; Royer & Cable, 1976; Sherman, 1976). In the study of the sixteen university courses, although a majority of the concepts were represented symbolically, several courses used enactive or iconic representation, and some courses were multi-modal. The sciences tended to be more enactive and iconic, and the social sciences were more exclusively symbolic. This suggests that more modes of representation are taken advantage of in science courses and that different or enriched patterns of cognitive structuring would develop.

Another area of experimentation in psychology that has produced valuable results for teaching is abstraction or concreteness. Abstraction is necessary for thinking: it allows the thinker a degree of autonomy from specific situations or episodes and produces a schema. The question in education is how to induce schema formation. Since concrete concepts contain fewer and less diffusely organized properties than do abstract concepts (O'Neill & Paivio, 1978), recall for concrete material tends to be superior. Thus, Posner and Strike (1974) note that a common principle in sequencing instruction is to teach the less abstract prior to the more abstract. Embedding abstract sentences in paragraphs with concrete referents to the material should also enhance learning and retention (Pezdek & Royer, 1974). The work on abstraction suggests an instructional paradox similar to that suggested by the varying amount of structure shown in the tree structures: more complex structures or more abstract concepts may be more difficult to learn,

but once learned, serve as patterns and thus make the following learning easier. The social science courses show an almost exclusive pattern of abstract concepts which may render courses in this area more difficult, but which may provide the learner with powerful conceptual instruments.

Close to abstraction is the process of generalization, and the generality or inclusiveness of a concept would be a measure of the expected ability to link or organize other concepts. The use of generalizations, either as "subsumers," that is, concepts which classify other terms in a category, or as mediators has been found to improve the learning of university students (Jacobson, Dickinson, Fleishman & Haraguchi, 1969; Ring & Novak, 1971). Those concepts rated as highly inclusive in a course could be expected to have the ability to link or organize other course concepts and to act as advance organizers in the course. Their purpose would be to establish in the student's conceptual structure the relevant anchoring ideas for learning material subsequently presented (Ausubel, 1968). Highly salient key concepts could also be used to cue or center attention. When prose is presented in colorful or forceful language, recall is higher than when the prose is not vivid (Montague & Carter, 1973). Berlyne (1965) maintained that learning is motivated by conflict which then leads to curiosity. It could be expected that more salient concepts would have a greater arousal or focussing power and thence would be more effective in gaining students' attention and holding it so that learning could occur.

One last experimental contribution that psychology has suggested to teaching is the effect of different relationships between concepts on teaching and learning. The study of relationships began with Aristotle's law of association based on the relationships of contiguity, similarity and contrast. Psychological research into cognitive development shows that the use of different kinds of relationships changes with cognitive development and level of intelligence. Young children and adolescents of normal intelligence tend to use contiguity as a basis for labelling or grouping instances of a concept (Donald, 1968; Kagan, Moss & Sigel, 1963; Rommetveit, 1960). Persons of greater cognitive development, in contrast, tend to use classification strategies with functional or subset relationships. More recently, cognitive scientists have produced taxonomies of relationships (Deese, 1965; Fredericksen, 1975; Rumelhart, 1975). Semantic theorists have used relationships such as incompatibility or exclusion, for example, the set of color terms; antonymy or opposites; subsets of genus and species; or consequence, for example, fire and smoke (Lyons, 1968). The most frequent basis of relationship is, however, similarity or likeness, according to Kintsch (1972). To study the relationships between concepts in university courses, a global taxonomy of relations was developed (see Table 3). Two broad sets of relationships were first defined, similarity and dependency or causal relationships. Similarity relationships included simple associative, functional, and structural, that is class or set relationships, while dependency relationships covered procedures and logical and

empirical causation.

The specific import of these results lies in the suggestions they make about the nature of the thought processes or strategies required to comprehend course material. The closest and most dominant kinds of relationships in a course could be expected to guide the organizing and analytic procedures that the student would have to have and to use in order to successfully incorporate the course material into his or her cognitive structure. Of the 252 relationships studied in the 16 courses, 60% were similarity relationships and 40% were dependency. The largest category of relationships was structural, that is, class or set, in which concepts had a hierarchical or taxonomic relationship. These relationships accounted for 42% of the total and were found in all the courses analyzed. This supports the attention paid to these kinds of relationships by Ausubel. Conversely, the finding that 58% of the relationships were not superordinate-subordinate explains why structural relationships alone cannot be used to describe the cognitive learning process. The sciences tended to have a higher proportion of procedural and causal relationships, and the social sciences displayed more logical relationships. Each course displayed its own pattern of relationships. A potentially valuable result of this analysis would be to provide students with advance notice of the kind of thought strategies which would be required in a particular course. This would be particularly useful in courses in which the pattern of relationships differs from the normal pattern exhibited in the discipline. For example, in the physical chemistry

course examined, instead of procedural or causal relationships between key concepts, as might be expected in a chemistry course, the links were found to be primarily structural (70%). This means that chemistry students would have to change the approach in their thinking in this course from that expected in other chemistry courses. Pointing out that different learning strategies are needed in this course would alert students and therefore alleviate the learning difficulty.

Synthesis

Overall, the contributions of psychology, theoretically, methodologically, and experimentally, to university teaching, from the perspective of educational epistemology, are those which provide answers to the question "What constitutes good learning in a course?" The study at McGill has suggested that the expressions "concept" and "cognitive structure" are useful to professors in describing what is to be learned and in representing it. The methods of evaluating concepts and the different forms of representation can be utilized across disciplines and will result in a set of core topics to be learned as well as cues for instruction and evaluation. The application of psychological principles and processes to teaching is neither easy nor direct; no synthesis is; but there exist all kinds of suggestions and findings in the psychological literature that merit examination and assimilation into our understanding of the teaching process.

Table 1

Numbers of Course Concepts

Course	Number of relevant concepts	Number of important concepts	Number of key concepts
Physics	123	59	15
Chemistry	170	20	20
Biology	89	50	12
Entomology	127	32	17
Geology	133	23	14
Psychology	140	40	14
Sociology	113	34	13
Political Science*	49	20	7
Educational Psychology	98	29	13
Social Work	138	54	18
Law*	68	25	11
Educational Evaluation*	82	14	14
History	101	39	16
English	58	20	13
Classics	34	10	10
Philosophy	33	12	12
Mean	99	30	14

* Two semester courses

Table 2

Familiarity of Key Concepts

Course	Mean % Technical	Mean occurrence/million (Kucera-Francis)	Mean number of word associations
Physics	53	22	7.1
Chemistry	30	63	6.9
Biology	100	10	7.7
Entomology	82	8	12.8
Geology	100	0.5	9.4
Psychology	57	27	7.9
Sociology	31	29	6.5
Political Science	71	18	5.6
Educational Psychology	54	10	12.7
Social Work	89	28	10.3
Law	82	25	10.3
Educational Evaluation	57	16	8.1
History	19	27	11.9
English	54	79	-
Classics	50	50	5.8
Philosophy	8	295	3.8

Table 3

Kinds of Relationships Between Concepts Linked in the Tree Structure

Relationship	N	Science (5)	Social Science (7)	Humanities (4)
Associative	34	14	10	10
Functional	13	0	7	6
Structural	105	48	37	20
Similarity	152	62	54	36
Procedural	24	20	3	1
Logical	48	12	30	6
Causal	28	15	6	7
Dependency	100	47	39	14
Total	252	109	93	50

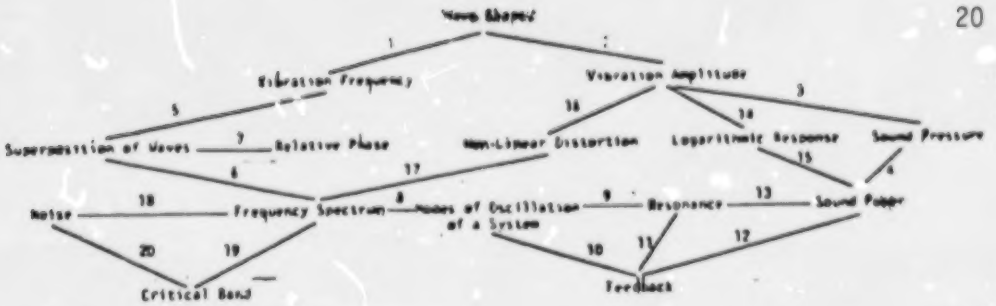

Figure 1. Tree structure of key concepts in a Physics course

BEST COPY AVAILABLE

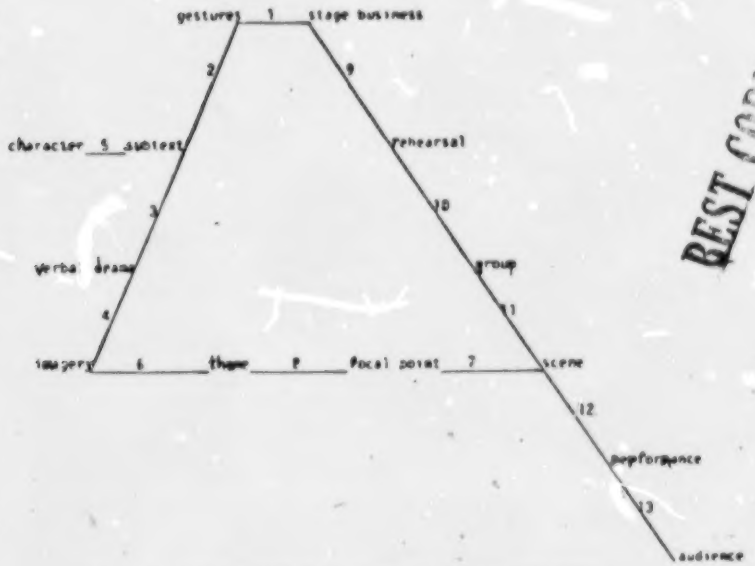

Figure 2. Tree structure of key concepts in an English course

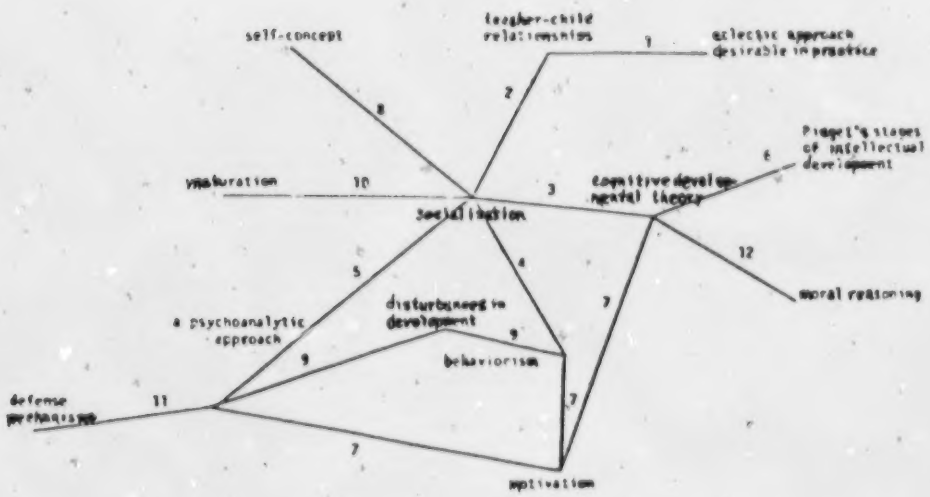

Figure 3. Tree structure of key concepts in a developmental Social Psychology course

References

Ausubel, D. P. Educational psychology: a cognitive view. New York: Holt, Rinehart & Winston, 1968.

Berlyne, D. E. Structure and direction in thinking. New York: Wiley, 1965.

Bower, G. H. Organizational factors in memory. Cognitive Psychology, 1970, 1, 18-46.

Bower, G. H. Selective facilitation and interference in retention of prose. Journal of Educational Psychology, 1974, 66, 1-8.

Bruner, J. The process of education. Cambridge, Mass.: Harvard University Press, 1960.

Bruner, J. S. The course of cognitive growth. American Psychology, 1964, 19, 1-15.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. A study of thinking. New York: Wiley, 1956.

Deese, J. The structure of associations in language and thought. Baltimore, Maryland: Johns Hopkins Press, 1965.

Donald, J. Concept identification: structuring responses to verbal and pictorial material. Doctoral Dissertation, 1968, 81 pp.

Eignor, D. R. Statistical suggestions for the study of cognitive structures. Paper presented at the annual meeting of the American Educational Research Association, Toronto, 1978.

English, H. B., & English, A. C. A comprehensive dictionary of psychological and psychoanalytic terms. New York: David McKay Company, 1958.

Frase, L. T. A structural analysis of the knowledge that results from thinking about text. Journal of Educational Psychology Monograph, 1969, 60(6).

Frederiksen, C. H. Effects of task-induced cognitive operations on comprehension and memory processes. In J. B. Carroll and R. O. Freedle (eds.), Language comprehension and the acquisition of knowledge. Washington, D.C.: V.H. Winston, 1972.

Frederiksen, C. H. Representing logical and semantic structure of knowledge acquired from discourse. Cognitive Psychology, 1975, 7, 371-458.

Garskof, B. E., & Houston, J. P. Measurement of verbal relatedness: an idiographic approach. Psychology Review, 1963, 70, 277-288.

Hildebrand, M., Wilson, R. C., & Dienst, E. R. Evaluating university teaching. Center for Research and Development in Higher Education, University of California, Berkeley, 1971.

Hunt, E. B. Concept learning: an information processing problem. New York: John Wiley, 1962.

Jacobson, L. I., Dickinson, T. C., Fleishman, J. M., & Haraguchi, R. S. Relationship of intelligence and mediating processes to concept learning. Journal of Educational Psychology, 1969, 60(2), 109-112.

Johnson, R. E. Meaningfulness and the recall of textual prose. American Educational Research Journal, 1973(b), 10, 49-58.

Kagan, J., Moss, H., & Sigel, J. Psychological significance of styles of conceptualization. In J. C. Wright & J. Kagan (eds)., Cognitive processes in children. Monograph of Social Research and Child Development, 1963, 28(2), serial no. 86, 73-112.

Kintsch, W. Notes on the structure of semantic memory. In Tulving, E., & Donaldson, W., Organization of memory. New York: Academic Press, 1972, 247-308.

Kintsch, W., & Keenan, J. Reading rate and retention as a function of the number of propositions in the base structure of sentences. Cognitive Psychology, 1973, 5, 257-274.

Kučera, H., & Francis, W. N. Computational analysis of present-day American English. Providence, Rhode Island: Brown University Press, 1967.

Lyons, J. Introduction to theoretical linguistics. Cambridge, 1968.

Marshall, G. R., & Cofer, C. N. Associative indices as measures of word relatedness: a summary and comparison of ten methods. Journal of Verbal Learning and Verbal Behavior, 1963, 1, 408-421.

McKeachie, W. J. Teaching tips: a guide book for the beginning college teacher. Lexington, Mass.: D.C. Heath & Co., 1969.

Meyer, B. J., & McConkie, C. W. What is recalled after hearing a passage? Journal of Educational Psychology, 1973, 65(1), 109-117.

Miller, G. A. Empirical methods in the study of semantics. In Steinberg, D. D., & Jacobovits, L. A. (eds.), Semantics: an interdisciplinary reader in philosophy, linguistics, and psychology. Cambridge: The University Press, 1971, 569-585.

Miller, R. B., Perry, F.L., & Cunningham, D. J. Differential forgetting of superordinate and subordinate information. Paper presented at the meeting of the American Educational Research Association, San Francisco, 1976.

Montague, W. E., & Carter, J. F. Vividness of imagery in recalling connected discourse. Journal of Educational Psychology, 1973, 64, 72-75.

Nelson, K. Cognitive development and the acquisition of concepts. In Anderson, R. C., Spiro, R. J., & Montague, W. E. (eds.), Schooling and the acquisition of knowledge. New Jersey: Lawrence Erlbaum Associates, 1977, 215-239.

Olson, D. R. The role of verbal rules in the cognitive processes of children. Unpublished Doctoral Thesis, University of Alberta, 1963.

O'Neill, B. J., & Paivio, A. Some consequences of violating selection restrictions in concrete and abstract sentences. Canadian Journal of Psychology, 1978, 32(1), 3-18.

Paivio, A. Language and knowledge of the world. Educational Researcher, 1974, 3(9), 5-12.

Pezdek, K., & Royer, J. M. The role of comprehension in learning concrete and abstract sentences. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 551-558.

Posner, G. J., & Strike, K. A. An analysis of curriculum structure. Paper presented at the meeting of the American Educational Research Association, Chicago, April, 1974.

Preece, P. F. W. Mapping cognitive structure: a comparison of methods. Journal of Educational Psychology, 1976, 68(1), 1-8.

Rapoport, A. A comparison of two tree-construction methods for obtaining proximity measures among words. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 884-890.

Rigney, J. W., & Lutz, K. A. Effect of graphic analogies of concepts in chemistry on learning and attitude. Journal of Educational Psychology, 1976, 68(3), 305-311.

Ring, D. G., & Novak, J. D. The effects of cognitive structure variables on achievement in college chemistry. Journal of Research in Science Teaching, 1971, 8(4), 325-333.

Rommetveit, R. Stages in concept formation and levels of cognitive functioning. Scandinavian Journal of Psychology, 1960, 1, 115-134.

Royer, J., & Cable. Illustrations, analogies, and facilitative transfer in prose learning. Journal of Educational Psychology, 1976, 68, 205-209.

Rubinstein, H., & Goodenough, J. B. Contextual correlates of synonymy. Comm. A C M, 1965, 8, 627-633.

Rumelhart, D. E. Notes on a schema for stories. In Bobrow, D. G., & Collins, Q.(eds.), Representation and understanding: studies in cognitive science. New York: Academic Press, 1975, 211-236.

Rumelhart, D., Lindsay, P., & Norman, D. A process model for long-term memory. In Tulving, E., & Donaldson, W., Organization of memory. New York: Academic Press, 1972.

Rumelhart, D. E., & Ortony, A. The representation of knowledge in memory. In Anderson, R. C., Spiro, R. J., & Montague, W. E. (eds.), Schooling and the acquisition of knowledge. New Jersey: Lawrence Erlbaum Associates, 1977.

Shavelson, R. J. Some methods for examining content structure and cognitive structure in instruction. Paper presented at the annual meeting of the American Educational Research Association, Chicago, April, 1974.

Sherman, J. L. Contextual information and prose comprehension. Journal of Reading Behavior, 1976, 8, 369-379.

Waern, Y. Structure in similarity matrices. Scandinavian Journal of Psychology, 1972, 13, 5-16.